

Simulation of Ferroelectric Memory Based Electronic Ceramic Material $(\text{Pb}_{0.9}\text{Ba}_{0.1})[(\text{Mn}_{0.5}\text{W}_{0.5})_x\text{Ti}_{1-x}]\text{O}_3$ for Storage Media

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ABSTRACT

Ferroelectric materials have attracted much attention for practical use as capacitors in non-volatile memories. In this dissertation we report the effect of simultaneous substitutions of manganese and tungsten on dielectric properties of modified lead titanate (dopants such as Mn and W is required to modify the hysteresis behavior i.e., to reduce the coercive field or to minimize aging) and simulating the dielectric constant, loss tangent with temperature as a function of frequency for the investigation of a suitable ferroelectrics material in the storage media. Ceramic compositions $(\text{Pb}_{0.9}\text{Ba}_{0.1})[(\text{Mn}_{0.5}\text{W}_{0.5})_x\text{Ti}_{1-x}]\text{O}_3$ with $x=0$ to 0.05 in steps of 0.01 were prepared by conventional ceramic route. XRD studies show that all the specimen to have single phase with tetragonal structure. Dielectric measurements were carried out as function of temperature and frequency. The room temperature value of dielectric constant and loss was increased with x . It is found that the value of transition temperature as well as tetragonal decreases with substitution of manganese and tungsten. Which indicates that the system $(\text{Pb}_{0.9}\text{Ba}_{0.1})[(\text{Mn}_{0.5}\text{W}_{0.5})_x\text{Ti}_{1-x}]\text{O}_3$ is a promising candidate for ferroelectric memory.

Keywords: Ferroelectric memory, $(\text{Pb}_{0.9}\text{Ba}_{0.1})[(\text{Mn}_{0.5}\text{W}_{0.5})_x\text{Ti}_{1-x}]\text{O}_3$, storage media.

INTRODUCTION

A computer system, whether a large machine or a microcomputer are requires memory for storing data and program instructions. Furthermore, within a given

computer system there usually is various types of memory utilizing a variety of technologies and having different access times. In general, computer memory can be divided into two types : main memory and mass-storage memory. The main memory is

usually the most rapidly accessible memory and the one from which most, often all, instructions in programs are executed. The main memory is usually of the random-access type. A random-access memory (RAM) is one in which the time required for storing (writing) information and for retrieving (reading) information is independent of the physical location (within the memory) in which the information is stored. A ferroelectric thin-film memory is constructed from an array of thin film capacitors. Ferroelectric thin films have attracted much attention for practical use as capacitors in nonvolatile, lower power consumption, higher endurance writing cycles and higher writing speed. Here a new ferroelectric memory based material has been proposed

EXPERIMENTAL

The experimental data taken by Rajesh K Katare *et al.* for the system $(\text{Pb}_{0.9}\text{Ba}_{0.1})(\text{Mn}_{0.5}\text{W}_{0.5})_x\text{Ti}_{1-x}\text{O}_3$ with $x=0$ to 0.05 in steps of 0.01. A green reactive mixture was prepared from AP grade oxide and carbonates. The weighed components were thoroughly mixed with distilled water in a ball mill. The mixtures were dried and calcined twice at 800°C for 4 Hrs followed by ball milling. Thin circular pellets (diameter 15mm, thickness 1mm) under a pressure of 50 kN/cm² were made and sintered at 1050°C for 4 Hrs in closed alumina crucibles in lead rich atmosphere. Silver paints were fired at 400°C on both the faces of the pellets to serve as electrodes for electrical measurements. The X-ray diffractograms (XRD) were obtained using Philips Diffractometer model PW-3020.

Dielectric properties (dielectric constant ϵ and dissipation factor $\tan\delta$) were measured using an LCR meter HP 4284 A as a function of frequency (100Hz-1MHz) and temperature (RT-500°C).

RESULT AND DISCUSSION

XRD analysis showed all the samples to be single phase with tetragonal structure. The lattice parameters were estimated using a standard computer program. The calculated d -values and experimentally observed d -values for those compounds were compared. A good agreement of calculated and observed d -values of all the diffraction lines for different compositions suggest that there is no change in basic crystal structure between pure and modified form PbTiO_3 . It is observed that the ratio of c/a (tetragonality) decreases with increasing amount of Mn^{2+} and W^{6+} at Ti-sites. As we know PbTiO_3 is a typical displacive ferroelectric material. In pure PbTiO_3 bulk phase the oxygen octahedron is deformed with large off center shift of the Ti^{4+} atom resulting in a large tetragonal $c/a = 1.064$. Doping manganese and tungsten into PbTiO_3 causes the migration of some additional point defects created by the substitution of Ti^{4+} site by manganese and tungsten ions. This makes slow deformation of the oxygen octahedron with a decrease of distance of the off center position Ti^{4+} and the center of the oxygen octahedron¹⁰ due to incorporation of manganese and tungsten vacancies into the Ti^{4+} sub lattice. Therefore, with increasing manganese and tungsten content the tetragonal of modified Lead Titanate material decreases. Dielectric properties

were measured for all the samples with respect to temperature up to well above the transition temperature (T_c) at five different frequencies. Dielectric constant increases with increase in temperature and shows a peak which is the characteristic of ferroelectrics material. The value of dielectric constant and dissipation factor decreases with frequency. The broad peak is observed up to $x \leq 0.04$ and there after one finds sharp and well developed peak at T_c for $x=0.05$ similar is the case for dissipation factor also. The reason for sharp end well – defined peak for $x \leq 0.05$ composition centered at 1050°C for 4 hrs. May be due to

the lowering of centric temperature (due to liquid phase transition) of PbTiO_3 with higher concentration of Manganese and tungsten. It is observed that the transition temperature T_c decreases with simultaneous substitution of Mn^{2+} and W^{6+} at Ti-sites. The room temperature value of ϵ' and $\tan\delta$ are found to increase with Manganese and tungsten concentration. One can observe that the value of remnant polarization decreases as we approach to the transition temperature with is normal characteristic of ferroelectrics system. The different parameters loops are listed in table 1.

TABLE1
PE loop properties for $x=0.05$ sample in the system $(\text{Pb}_{0.9}\text{Ba}_{0.1})(\text{Mn}_{0.5}\text{W}_{0.5})_x\text{Ti}_{1-x}\text{O}_3$

Temperature ($^\circ\text{C}$)	Coercive field E_c (kV/cm)	Remanence Polarization P_r (mC/cm ²)	Pr/Ps
30	3.098	12.247	0.342
85	2.946	8.787	0.279
110	3.209	4.437	0.176
130	3.194	2.843	0.150

CONCLUSION

The present study it is observed that the tetragonality (c/a) and transition temperature decreases with simultaneous substitution of manganese and tungsten in modified PT system. The room temperature value of dielectric constant and dissipation factor increases with x . These features render the ceramics system $(\text{Pb}_{0.9}\text{Ba}_{0.1})(\text{Mn}_{0.5}\text{W}_{0.5})_x\text{Ti}_{1-x}\text{O}_3$ as an extremely useful materials and it shows is a promising candidate for ferroelectric memory.

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389 Rajesh Kumar Katare, *et al.*, J. Pure Appl. & Ind. Phys. Vol.2 (3A), 386-389 (2012)

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